Do we need high field MR-scanner for routine imaging of the lumbar spine?

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Introduction and Aim :

Today MR-scanners are used with different magnetic field strength ranging from 0,2 to 7,0 Tesla. There are only few studies which compare the imaging results from   different field strength.

The aim of this study is to compare image quality and diagnostic reliability of the MR-examination of the lumbar spine carried out with low, intermediate and high field strength.
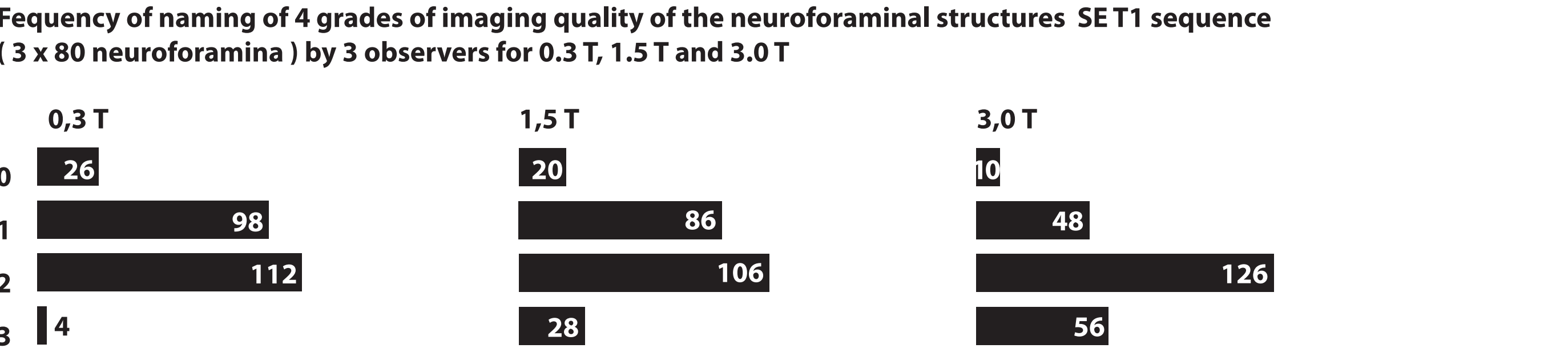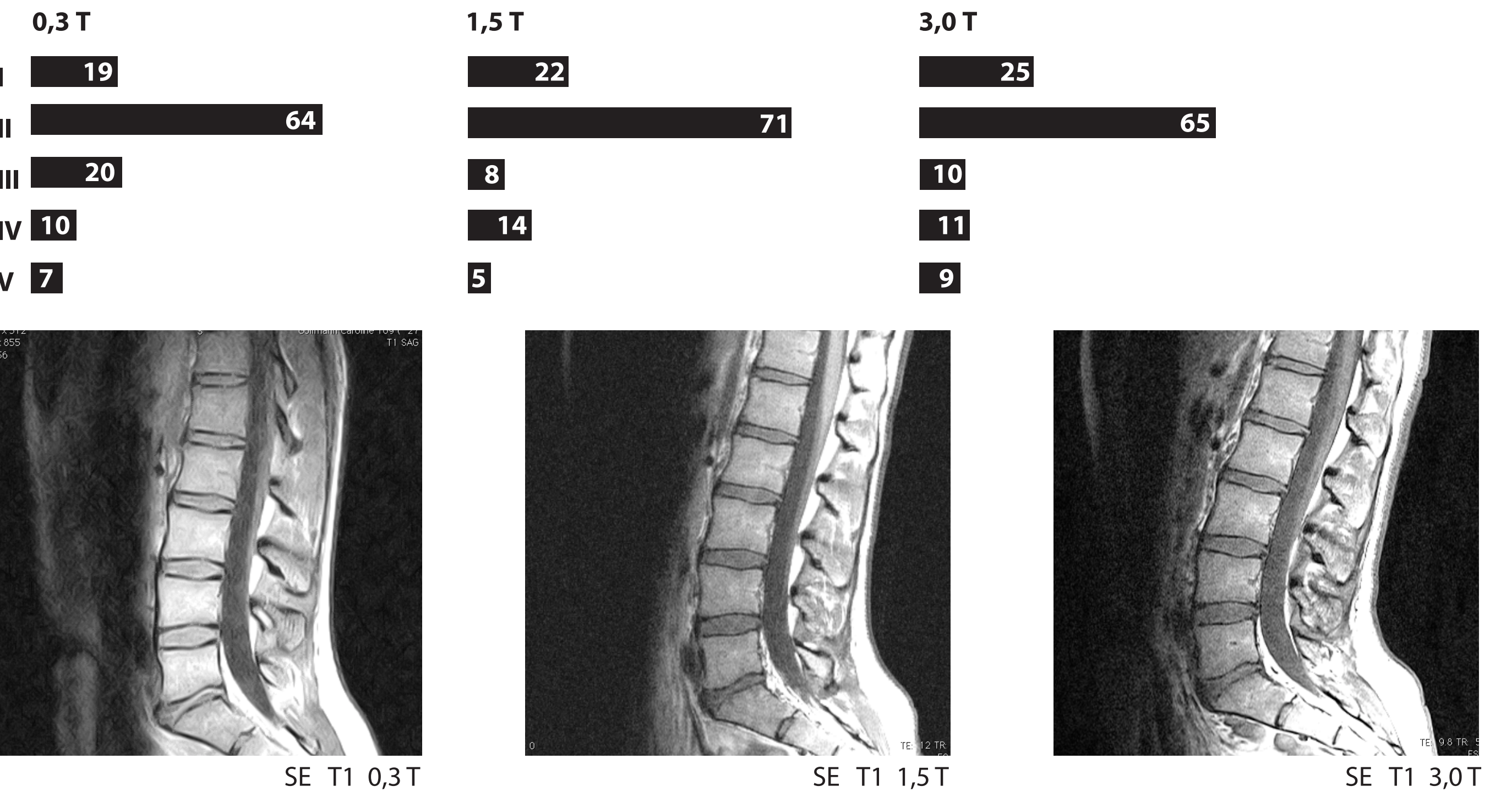
Material and Methods :

Each of 8 volunteers (7 female, 1 male, ageing from 24 y to 57 y) were scanned with 0,3 T (Hitachi AIRIS VENTO), 1,5 T (Siemens SYMPHONY) and 3,0 T (Siemens MAGNETOM TRIO) scanner with sequences adjusted to give similar tissue contrast (STIR sag, SE T1 sag and trans, SE T2 sag and trans). The image quality of the following structures were estimated with a 4 point scale (0 = not recognized, 1= recognized with flat contours, 2 = recognized and well delineated, 3 = recognized, well delineated and with high contrast to adj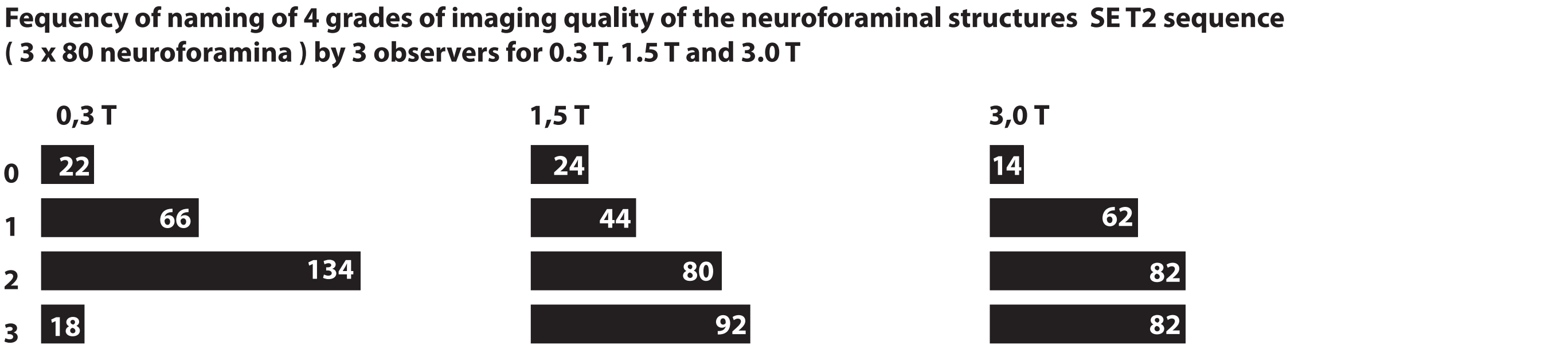acent tissues) : neuroforaminal structures as fat pad, nerve root pouch and ganglion, dural sack and spinal canal, disc, vertebra and facet joint with lig. flavum. Pfirrmann scale was used to classify disc degeneration. Hydration of the disc was evaluated by the quotient : mean voxel value of the disc divided by mean voxel value of the adjacent liquor (mid sagittal plane, cm 2). The evaluation was done by two MR-experts and one orthopaedic spinal surgeon.
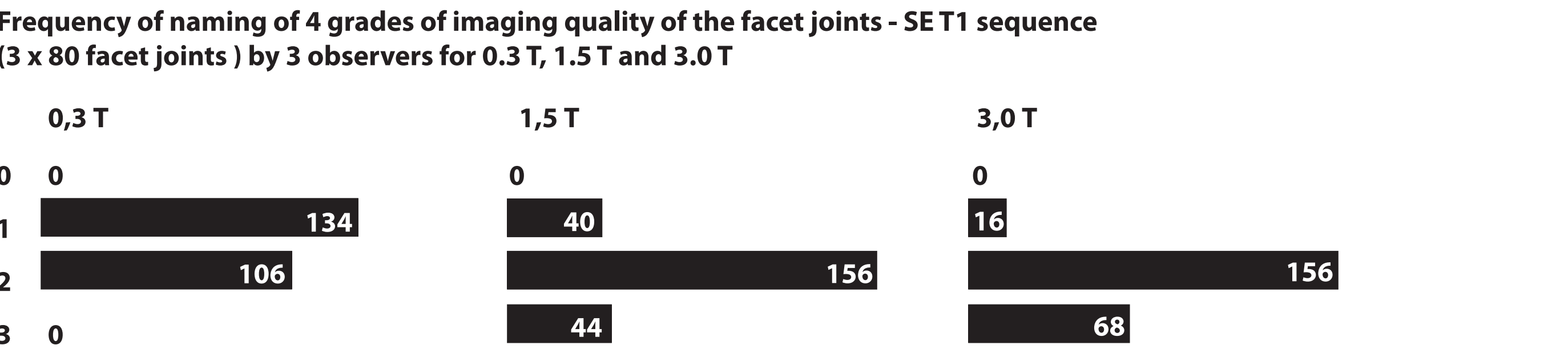
Results:

Frequency of naming the 5 grades of Pfirrmann scale (3 x 40 discs) by 3 observer for 0.3 T, 1.5 T and 3.0 T
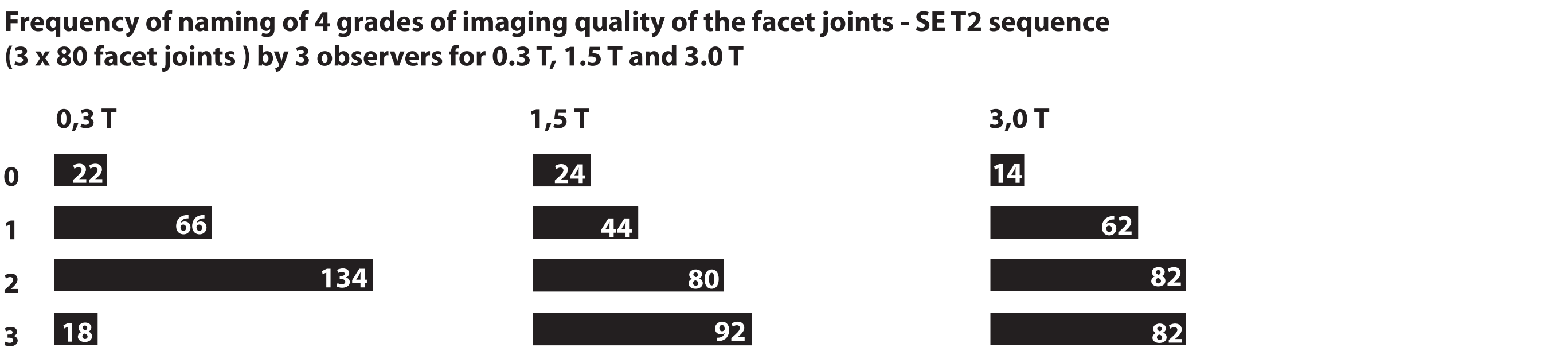
	0,3 T	1,5 T	3,0 T
I	19	22	25
II	64	71	65
III	20	8	10
IV	10	14	11
V	7	5	9

	0,3 T	1,5 T	3,0 T
I +II	83	93	90
III+IV+V	37	27	30

Kappa value for disc degeneration (3 x 40 discs) :
0,3 T : 0,72
1,5 T : 0,83
3,0 T : 0,95

SE T1 0,3 T   SE T1 1,5 T   SE T1 3,0 T

STIR 0,3 T   STIR 1,5 T   STIR 3,0 T

Frequency of naming of 4 grades of imaging quality of the neuroforaminal structures SE T1 sequence (3 x 80 neuroforamina) by 3 observers for 0.3 T, 1.5 T and 3.0 T

	0,3 T	1,5 T	3,0 T
0	26	20	10
1	98	86	48
2	112	106	126
3	4	28	56

Kappa value for imaging quality of the neuroforaminal structures - SE T1 sequence (3 x 80 neuroforamina) :
0,3 T : 0,45
1,5 T : 0,64
3,0 T : 0,5

Frequency of naming of 4 grades of imaging quality of the neuroforaminal structures SE T2 sequence (3 x 80 neuroforamina) by 3 observers for 0.3 T, 1.5 T and 3.0 T

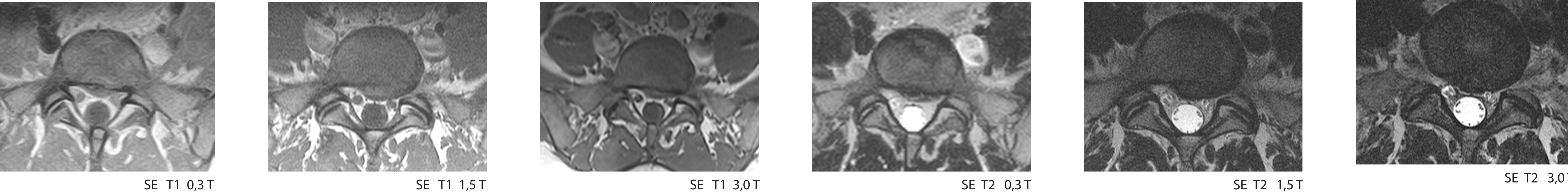|	0,3 T	1,5 T	3,0 T
0	22	24	14
1	66	44	62
2	134	80	82
3	18	92	82

Kappa value for imaging quality of the neuroforaminal structures - SE T2 sequence (3 x 80 neuroforamina) :
0,3 T : 0,42
1,5 T : 0,74
3,0 T : 0,59

Frequency of naming of 4 grades of imaging quality of the facet joints - SE T1 sequence (3 x 80 facet joints) by 3 observers for 0.3 T, 1.5 T and 3.0 T

	0,3 T	1,5 T	3,0 T
0	0	0	0
1	134	40	16
2	106	156	156
3	0	44	68

Kappa value for the imaging quality of the facet joints - SE T1 sequence (3 x 80 facet joints) :
0,3 T 0,80
1,5 T 0,67
3,0 T 0,63

Frequency of naming of 4 grades of imaging quality of the facet joints - SE T2 sequence (3 x 80 facet joints) by 3 observers for 0.3 T, 1.5 T and 3.0 T

	0,3 T	1,5 T	3,0 T
0	22	24	14
1	66	44	62
2	134	80	82
3	18	92	82

Kappa value for the imaging quality of the facet joints - SE T2 sequence (3 x 80 facet joints) :
0,3 T 0,42
1,5 T 0,74
3,0 T 0,59

SE T1 0,3 T   SE T1 1,5 T   SE T1 3,0 T

SE T2 0,3 T   SE T2 1,5 T   SE T2 3,0 T

Hydration index - mean value (MV) and standard deviation (SD) - for disc degeneration :

		0,3 T		1,5 T		3,0 T	
Pfirrmann	I	MV 29,8	SD 8,1	MV 41,3	SD 12,1	MV 34,4	SD 7,7
	II	MV 27,3	SD 7,0	MV 41,5	SD 6,2	MV 29,8	SD 7,7
	III	MV 18,3	SD 4,9	MV 19,5	SD 7,8	MV 24,7	SD 4,2
	IV	MV 8,7	SD 2,0	MV 27,0	SD 16,3	MV 12,5	SD 5,3
	V	8,0		14,0		MV 6,3	SD 3,1

Discussion:

The diagnostic review for all 8 volunteers was identical for the 3 different scanners and for the 3 reviewers concerning disc degeneration, herniation, facet arthrosis and spinal canal narrowing. There was a good agreement in the frequency of naming for the Pfirrmann scale if grade I and II were taken together and also III, IV and V, which is reasonable because grade I and II are quite normal discs. Internal structures of the discs were better delineated in the T1 weighted images by the 0,3 T scanner. The Kappa values for image quality of the neuroforaminal structures are poor as for T2 as for T1 sequences. This is mainly due to the influence of subjective impressions. The frequency of naming shows a good agreement between the grade 0 (not delineated) and the rest of the scale (delineated with different quality) for the three scanners . There is some better quality for higher field strength. The Kappa values for imaging of the facet joints are quite good for all scanners and both sequences except for the 0,3 scanner with T1 sequence. The frequency of naming indicate some higher quality by higher field strength. Changes of signal intensities in the vertebras near the endplates were delineated with significantly less extend and contrast by the 0,3 T scanner. Contrast between disc and liquor was higher in STIR images of the 0,3 T scanner. Scan time was 45 min for the 0,3T, 29 min for the 1,5 T and 31 min for the 3,0 T scanner. The annual costs, calculated for the german market for 7 years of amortization are 135750 Euro for the 0,3 T, 286050 Euro for the 1,5 T, and 401100 Euro for the 3,0 T scanner.

Conclusion:

For routine MR diagnostic of the lumbar spine a low field scanner is sufficient. Costs are lower but scan time is 30% higher.